

AMENDMENTS TO THE CLAIMS

1. (Currently Amended) A method for calculating a future cost for use in routing an integrated circuit, the conductors in the integrated circuit being modeled by a plurality of nodes and at least one source node, the method comprising:

obtaining a first node from the plurality of nodes;

obtaining a second node that can be electrically connected to the first node;

determining a cumulative routing cost of the second node;

calculating a first distance between the second node and the source node, wherein first distance is less than a predetermined value; and

setting the future cost equal to the cumulative routing cost if there is no existing future cost that corresponds to the distance or if the cumulative routing cost is less than the existing future cost corresponding to the distance; and

calculating a first cost slope as a function of the cumulative routing cost divided by the first distance and recording the first cost slope in a memory location for use as a future cost value associated with a first predetermined maximum distance.

2. (Original) The method of claim 1 wherein the first distance is a Manhattan distance.

3. (Original) The method of claim 1 wherein the cumulative routing cost of the second node comprises a cumulative routing cost of the first node and a routing cost of the second node.

4. (Original) The method of claim 1 wherein the first node is a source node.

5. (Original) The method of claim 4 wherein the source node is located at one corner of the integrated circuit.

Claims 6-7. (Cancelled)

8. (Currently Amended) The method of claim 1 ~~[[7]]~~ further comprising:

~~providing a memory location for storing a cost slope value;~~
recording the first cost slope in the memory location if the first cost slope is smaller than the cost slope value stored in the memory location or if there is no existing cost slope value in the memory location.

9. (Original) The method of claim 1 further comprising:
generating a two dimensional array;

calculating a second distance between the second node and the source node, the second distance being in an orientation substantially perpendicular to the first distance; and

storing the future cost in a position of the array determined by the first and the second distances.

10. (Original) The method of claim 9 wherein the first and the second distances are Manhattan distances.

11. (Original) The method of claim 9 wherein the cumulative routing cost of the second node comprises a cumulative routing cost of the first node and a routing cost of the second node.

12. (Original) The method of claim 9 wherein the first and the second distances are less than predetermined values.

13. (Currently Amended) The method of claim 12, wherein the first predetermined maximum distance is in a first dimension and further comprising the step of ~~calculating a first cost slope using the cumulative routing cost and the first distance and~~ calculating a second cost slope as a function of using the cumulative routing cost divided by ~~[[and]]~~ the second distance and recording the second cost slope in a memory location for use

as a future cost value associated with a second predetermined maximum distance in a second dimension.

14. (Currently Amended) The method of claim 13 further comprising:

~~providing a first memory location for storing a first value and a second memory location for storing a second value;~~

recording the first cost slope in the first memory location if the first cost slope is smaller than the first value in the location; and

recording the second cost slope in the second memory location if the second cost slope is smaller than the second value in the location.

15. (Original) The method of claim 9 wherein the array is stored in a memory device, and the array is later retrieved from the memory device to perform the routing.

16. (Currently Amended) A method for calculating a future cost for use in routing an integrated circuit, the conductors in the integrated circuit being modeled by a plurality of nodes, the method comprising:

creating a queue;

placing a source node into the queue; and

performing the following steps until the queue is empty:

selecting a low cost node from the queue, the low cost node having lowest cumulative routing cost of all nodes in the queue;

obtaining a neighboring node that can be electrically connected to the low cost node and is unvisited;

determining a cumulative routing cost of the neighboring node;

calculating a first distance between the neighboring node and the source node, wherein first distance is less than a predetermined value;

adding the neighboring node to the queue;

setting the future cost equal to the cumulative routing cost if there is no existing future cost that corresponds to the

first distance or if the cumulative routing cost is less than the existing future cost; [[and]]

calculating a first cost slope as a function of the cumulative routing cost divided by the first distance and storing the first cost slope for use as a future cost value associated with a first predetermined maximum distance; and

repeating the obtaining, determining, calculating a first distance, adding, [[and]] setting, calculating a first cost slope, and storing the first cost slope steps until substantially all unvisited nodes neighboring the low cost node have been considered.

17. (Original) The method of claim 16 wherein the first distance is a Manhattan distance.

18. (Original) The method of claim 16 wherein the cumulative routing cost of the neighboring node comprises a cumulative routing cost of the low cost node and a routing cost of the neighboring node.

Claims 19-20. (Cancelled)

21. (Currently Amended) The method of claim 16 [[20]] further comprising:

~~providing a memory location for storing a cost slope value;~~
recording the first cost slope in the memory location if the first cost slope is smaller than the cost slope value stored in the memory location.

22. (Original) The method of claim 21 further comprising:

generating a two dimensional array;
calculating a second distance between the neighboring node and the source node, the second distance being in an orientation substantially perpendicular to the first distance; and
storing the future cost in a position of the array determined by the first and the second distances.

23. (Original) The method of claim 22 wherein the first and the second distances are Manhattan distances.

24. (Original) The method of claim 22 wherein the first and the second distances are less than predetermined values.

25. (Currently Amended) The method of claim 24, wherein the first predetermined maximum distance is in a first dimension and further comprising the step of calculating a first cost slope using the cumulative routing cost and the first distance and calculating a second cost slope as a function of using the cumulative routing cost divided by [[and]]the second distance and recording the second cost slope in a memory location for use as a future cost value associated with a second predetermined maximum distance in a second dimension.

26. (Currently Amended) The method of claim 25 further comprising:

~~providing a first memory location for storing a first value and a second memory location for storing a second value;~~

recording the first cost slope in [[a]] ~~the first memory~~ location if the first cost slope is smaller than the first value in the location; and

recording the second cost slope in [[a]] ~~the second memory~~ location if the second cost slope is smaller than the second value in the location.

27. (Original) The method of claim 22 wherein the array is stored in a memory device, and the array is later retrieved from the memory device to perform the routing.

28. (Original) A method for routing signals in an integrated circuit, the integrated circuit being modeled by a plurality of nodes, the method comprising:

generating an array;

calculating a plurality of future costs and a plurality of associated distances, each of the distances being less than a predetermined value;

storing the plurality of future costs in separate places in the array based on their associated distances;

determining a cost slope using the plurality of future costs and the associated distances;

performing routing using a cost that includes the plurality of future costs if a distance from a node to a target node is less than the predetermined value and values calculating from the cost slope otherwise.

29. (Original) The method of claim 28 wherein the plurality of distances are Manhattan distances.

30. (New) A method for establishing future cost values for use in routing signals of a circuit design on an integrated circuit, comprising:

selecting a pre-routing source node from a graph of nodes that represents conductors in a device;

determining for each node in the graph, a respective minimum future cost value as a function of a cumulative cost of nodes on a path from the pre-routing source node to the node; and

storing each future cost value in a location that is addressable as a function of a distance from the node from which the future cost value was determined to the pre-routing source node.

31. (New) The method of claim 30, further comprising:

wherein the storing step includes,

establishing a two-dimensional table for storage of the future cost values;

determining a Manhattan distance from the node from which the future cost value was determined to the pre-routing source node; and

storing each future cost value in the two-dimensional table at a location indexed by the Manhattan distance.

32. (New) The method of claim 31, wherein the integrated circuit is a field-programmable gate array (FPGA) and the pre-route source node is a node that represents an output pin of a configurable logic block (CLB).

33. (New) The method of claim 32, wherein the CLB is a corner CLB.

34. (New) The method of claim 31, further comprising, for two nodes being equal distance from the pre-routing source node and having respectively determined future cost values, storing a lesser of the respective future cost value in association with the distance.

35. (New) The method of claim 31, further comprising:
establishing an upper bound distance for which the future cost values are determined; and
estimating a future cost value of a node for which the distance from the node to the target node is greater than the upper bound distance.

36. (New) An apparatus for establishing future cost values of for use in routing signals of a circuit design on an integrated circuit, comprising:

means for selecting a pre-routing source node from a graph of nodes that represents conductors in a device;

means for determining for each node in a graph a respective minimum future cost value as a function of a cumulative cost of nodes on a path from the pre-routing source node to the node;
and

means for storing each future cost value in a location that is addressable as a function of a distance from the node from

which the future cost value was determined to the pre-routing source node.

37. (New) A method for routing signals of a circuit design on an integrated circuit, comprising:

- selecting a pre-routing source node from a graph of nodes that represents conductors in a device;

- determining for each node in the graph, a respective minimum future cost value as a function of a cumulative cost of nodes on a path from the pre-routing source node to the node;

- storing each future cost value in a location that is addressable as a function of a distance from the node from which the future cost value was determined to the pre-routing source node;

- for each signal in the design having an assigned signal source node and at least one target node to which the signal is to be routed, selecting a path from the signal source node to the target node from a plurality of candidate paths as a function of relative cost values of the candidate paths, wherein the selecting includes,

- determining for each node in each candidate path, a distance from that node to the target node and a future cost value associated with the distance;

- determining for each node in each candidate path, an associated node cost value; and

- determining a cost value of each candidate path as a function of each future cost value and node cost value of each node in the candidate path.

38. (New) The method of claim 37, further comprising:

- wherein the storing step includes,

- establishing a two-dimensional table for storage of the future cost values;

- determining a Manhattan distance from the node from which the future cost value was determined to the pre-routing source node; and

storing each future cost value in the two-dimensional table at a location indexed by the Manhattan distance;

and the step of determining the future cost value of a node in a candidate path includes,

determining a Manhattan distance from that node to the target node; and

reading from the two-dimensional table a future cost value indexed by the Manhattan distance.

39. (New) The method of claim 38, wherein the integrated circuit is a field-programmable gate array (FPGA) and the pre-route source node is a node that represents an output pin of a configurable logic block (CLB).

40. (New) The method of claim 39, wherein the CLB is a corner CLB.

41. (New) The method of claim 38, further comprising, for two nodes being equal distance from the pre-routing source node and having respectively determined future cost values, storing a lesser of the respective future cost value in association with the distance.

42. (New) The method of claim 38, further comprising:
establishing an upper bound distance for which the future cost values are determined; and
estimating a future cost value of a node for which the distance from the node to the target node is greater than the upper bound distance.

43. (New) An apparatus for routing signals of a circuit design on an integrated circuit, comprising:

means for selecting a pre-routing source node from a graph of nodes that represents conductors in a device;

means for determining for each node in a graph a respective minimum future cost value as a function of a cumulative cost of nodes on a path from the pre-routing source node to the node;

means for storing each future cost value in association with a distance from the node from which the future cost value was determined to the pre-routing source node;

means, responsive to each signal specified in the design having an assigned signal source node and at least one target node to which the signal is to be routed, for selecting a path from the signal source node to the target node from a plurality of candidate paths as a function of relative cost values of the candidate paths, wherein the selecting means includes,

means for determining for each node in each candidate path, a distance from that node to the target node and a future cost value associated with the distance;

means for determining for each node in each candidate path, an associated node cost value; and

means for determining a cost value of each candidate path as a function of each future cost value and node cost value of each node in the candidate path.